REMARKS

In the office action, the examiner rejected all claims (1-18) as obvious over Wheeler, et al., (paper presented at 1999 SPE Reservoir Simulation Symposium in Houston, Feb. 14-17), in view of U.S. Patent No. 6,152,226 to Talwani, et al. and U.S. Patent No. 4,860,828 to Oswald, et al. Applicants respectfully traverse the examiner's rejection of said claims, and request that the examiner re-examine and reconsider the application in the light of the following comments.

Applicants contend that the Examiner has misunderstood the teachings of Wheeler, Talwani and Oswald, or the teachings of the present application, or both.

The present application relates to a method and system for simulating a hydrocarbon-bearing formation under conditions in which a fluid is injected into the formation to displace resident hydrocarbons. The method of the application is especially useful in modeling the effects of viscous fingering and channeling as the injected fluid flows through a hydrocarbon-bearing formation.

In contrast, Wheeler, Talwani, and Oswald relate to distinctly different areas of art. Wheeler describes an approach for organizing the gridcells in a reservoir simulation model to achieve computational efficiency on a parallel-computing machine. Talwani and Oswald do not teach reservoir simulation or other computer-performed calculations at all. Talwani describes a method for monitoring the subsurface boundary between to-be-recovered oil and the reservoir drive fluid using repeated gravity gradient surveys. Oswald describes a method for improving the sweep efficiency of a gas flood oil recovery process using a mixture of an alkylated diphenyl sulfonate and an alpha–olefin sulfonate as the surfactants in a mobility control fluid or diverter. Talmani and Oswald cannot possibly, and do not, teach any steps in a calculational method such as Applicants' method. Talmani and Oswald teach steps in a physical process.

Oswald teaches how to select the compositions of the best fluids to inject into a hydrocarbon formation. This has nothing to do with simulating the response of the hydrocarbons in the formation to such injection. Talwani teaches to make gravity gradient measurements over a secondary recovery field operation, using a device called a gravity gradiometer, concluding from those measurements where the interface between the hydrocarbons and the injected fluid is, and using that information to control the fluid injection. This is not a reservoir simulation model.

Wheeler teaches step (a) of Applicants' claim 1, a fundamental step in the construction of any reservoir simulation model. The examiner acknowledges that Wheeler teaches neither step (b) nor step (c) of Applicants' claim 1. Therefore, the examiner must rely on Talwani or Oswald for disclosure of these two steps. Neither reference provides the disclosures the examiner needs, as will be made apparent in the paragraphs to follow. Neither invention has anything to do with the features of steps (b) or (c). Step (b) calls for dividing some of the grid cells (from step (a)) into two or more regions. Neither Talwani nor Oswald write of grid cells (because the methods they teach are not calculational techniques requiring discretization of a region into small cells). It is difficult to know where in Talwani or Oswald the examiner thinks to have found Applicants' step (b). To speculate, the examiner may misunderstand Talwani's discussion of monitoring the interface between the to-be-recovered oil and driving fluid using gravity gradient surveys performed using instruments at the earth's surface. The results of such a sequence of surveys may be useful for validation or calibration of a reservoir simulation model, but nowhere does Talwani teach a method for dividing gridcells in a subterranean reservoir simulation model.

Applicants' step (c) has three parts. A model is constructed that is representative of (i) fluid properties within each region, (ii) fluid flow between gridcells using principles of percolation theory, and (iii) component transport rate between regions. Step (c)(i) of Applicants' claim I calls for constructing a model representative of fluid properties (such as phase volumes, densities, compositions, and viscosities) within each of the regions defined in step (b). Preferably, an equation of state is used to predict fluid properties in

each region. This is disclosed and taught in the present application at page 15, line 26 through page 16, line 6 and page 28, line 5 through page 30, line 4. Nowhere does Talwani or Oswald teach a method for constructing a model representative of fluid properties in sub-gridcell regions.

Step (c)(ii) of Applicants' claim 1 is a method for constructing a model representative of fluid flow between gridcells using the principles of percolation theory. As explained in the present application at page 15, lines 10 through 25 and page 26, line 7 through page 28, line 2, Applicants use the term "percolation theory" to refer to specific known techniques for describing critical phenomena, conductance, diffusion, and flow in disordered heterogeneous systems (see for example, Shante, V. K. S., and Kirkpatrick, S., "An Introduction to Percolation Theory," *Adv. Phys.*, **20**, 325-57 (1971); Kirkpatrick, S., "Classical Transport in Disordered Media: Scaling and Effective-Medium Theories," *Phys. Rev. Lett.*, 27 (1971); Kirkpatrick, S., "Percolation and Conduction," *Rev. Mod. Phys.*, **45**, 574-88 (1973); Mohanty, K. K., Ottino, J. M. and Davis, H. T., "Reaction and Transport in Disordered Composite Media: Introduction of Percolation Concepts," *Chem. Engng. Sci.*, **37**, 905-24 (1982); and Sahimi, M., Hughes, B. D., Scriven, L. E. and Davis, H. T., "Stochastic Transport in Disordered Systems," *J. Chem. Phys.*, **78**, 6849-64 (1983)).

As a simple example illustrating those features of percolation theory of relevance here, consider a very large, essentially infinite sheet of non-conducting material divided into identical square cells. At random, a fraction of the cells containing non-conductor are replaced with cells containing a conductor. If the fraction is small, most of the conducting cells occur as monomers – with no conducting cells as nearest neighbors. In particular, there is no continuous path of conducting cells long enough to span the sheet and, therefore, the sheet as a whole is non-conducting. As the fraction of conducting cells is increased, however, dimers, trimers, and larger clusters of connected conducting cells appear, until at some critical fraction, there appears an infinite cluster spanning the entire sheet. At this critical fraction, X_c, called the percolation threshold of the medium, the sheet becomes a conductor. Percolation

theory provides mathematical methods for calculating the percolation threshold and effective conductivity of such a random heterogeneous system. The effective medium approximation is one such mathematical method in which the conductivity of a random heterogeneous medium is represented by the conductivity of an equivalent (effective) homogeneous medium.

The present application thus discloses use of percolation theory, and in particular, the effective medium approximation, in reservoir simulation to represent viscous fingering and channeling using large gridcells. In the context of the example above, the low-mobility resident oil is analogous to the non-conductor and the high-mobility invading gas or solvent is analogous to the conductor. The large gridcell is subdivided into a network of smaller gridcells, each of which contains either invading or resident fluid, to represent the fine-scale distribution of the two fluids within the large gridcell. The effective medium approximation then is used to estimate the effective coarse-scale fluid mobility, which is analogous to the effective conductivity of the essentially infinite sheet in the simple example above.

The portions of Talwani (col. 1, lines 42-56 and col. 6, lines 38-50) cited by the examiner as teaching Applicants' claim (c)(ii) are general background descriptions of primary and secondary oil recovery process. To describe these processes, the examiner uses the word "percolation" in the broad, general sense of flow through porous media. Nowhere does Talwani teach the division of a large gridcell into a network of smaller gridcells to represent the fine-scale distribution of fluids within the large gridcell and then using any of the specific known techniques of percolation theory to represent viscous fingering and channeling in large gridcells in a subterranean reservoir simulation model. Nor does Oswald discuss or suggest this topic.

Step (c)(iii) of Applicants' claim 1 is a method for constructing a model representative of component transport rate between the reservoir gridcell regions defined in step (b). As disclosed in the present application at page 16, lines 7 through 22 and page 22, line 23 through page 26, line 5, this step relates to modeling the rate of

transport (transfer) of components (chemical species) between the two reservoir gridcell regions when the components have unequal concentrations in the two regions. The portions of Talwani (col. 9, lines 32-41) cited by examiner as teaching step (c)(iii) of Applicants' claim 1 describe the differences between uniaxis gravimeters and gravity gradiometers, instruments used at the surface of the earth to measure, respectively, the gravity field along the vertical axis and various types of gravity gradients. It is unclear how a description of instruments used to make gravity measurements at the earth's surface relates to modeling transport between gridcell regions in a subterranean reservoir simulation model. Nowhere does either Talwani or Oswald teach a method for modeling the rate of transport of components between two gridcell regions in a subterranean reservoir simulation model when the components have unequal concentrations in the two regions.

Because they do not teach construction or use of any simulation model, neither Talwani nor Oswald can teach Applicants' step (d), which is using the model to simulate one or more characteristics of the formation.

It is unclear which step in Applicants' claim 1 is thought by the examiner to be disclosed by Oswald. In fact, Oswald does not teach any of the steps of Applicants' claim 1. Oswald teaches a method for recovering hydrocarbons from a subterranean formation by improving the sweep efficiency of the gas in gas flooding or miscible gas flooding operations. The recovery method comprises injecting, under non-steam flood conditions, sequentially or simultaneously, through an injection well, a drive fluid of a gas or a gas/aqueous fluid mixture to drive the hydrocarbons, or a miscible fluid to thin or solubilize and carry the hydrocarbons, from the formation to a producing well; and a mobility control fluid comprising a surfactant/water mixture, wherein the surfactant component of the mobility control fluid is a mixture of at least one alkylated diphenyl sulfonate and at least one alpha-olefin sulfonate, into the subterranean formation.

It will be readily obvious that the preceding arguments apply equally to the rejection of Applicants' other independent claims (14, 16 and 18).

CONCLUSION

Each of the claims of the present application are believed to be patentably distinct from all known prior art, including all art cited by the examiner. Therefore, Applicants respectfully request allowance of all claims.

If the Examiner wishes to discuss this application with counsel, please contact the undersigned.

Respectfully submitted,

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I hereby certify that this correspondence is being transmitted via facsimile to Examiner Rosales Hanner, Technology Center 2100, United States Patent and Trademark Office at (703) 872-9306 on September 16, 2004.

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